Chemical Manufacturing, Except Pharmaceutical and Medicine Manufacturing

(NAICS 325, except 3254)

SIGNIFICANT POINTS

- Employment is projected to decline.
- Workers involved in production and installation, maintenance, and repair hold about half of all jobs.
- Persons with technical and advanced degrees will have the best opportunities.
- Production workers earn more than in most industries.

Nature of the Industry

Chemicals are an essential component of manufacturing, vital to industries such as construction, motor vehicles, paper, electronics, transportation, agriculture, and pharmaceuticals. Although some chemical manufacturers produce and sell consumer products such as soap, bleach, and cosmetics, most chemical products are used as intermediate products for other goods.

Chemical manufacturing is divided into seven segments, six of which are covered here: Basic chemicals; synthetic materials, including resin, synthetic rubber, and artificial and synthetic fibers and filaments; agricultural chemicals, including pesticides, fertilizer, and other agricultural chemicals; paint, coating, and adhesives; cleaning preparations, including soap, cleaning compounds, and toilet preparations; and other chemical products. The seventh segment, pharmaceutical and medicine manufacturing, is covered in a separate *Career Guide* statement.

The basic chemicals segment produces various petrochemicals, gases, dyes, and pigments. Petrochemicals are chemicals that contain carbon and hydrogen and are made primarily from petroleum and natural gas. The production of both organic and inorganic chemicals is discussed in this segment. Organic chemicals are used to make a wide range of products, such as dyes, plastics, and pharmaceutical products; however, the majority of these chemicals are used in the production of other chemicals. Industrial inorganic chemicals usually are made from salts, metal compounds, other minerals, and the atmosphere. In addition to solid and liquid chemicals, firms involved in inorganic chemical manufacturing also produce industrial gases such as oxygen, nitrogen, and helium. Many inorganic chemicals serve as processing ingredients in the manufacture of chemicals, but do not appear in the final products because they are used as reaction aids.

The synthetic materials segment produces a wide variety of finished products as well as raw materials. Some of these include common plastics materials such as polyethylene, polypropylene, polyvinyl chloride (PVC), and polystyrene, which can be made into products such as loudspeakers, toys, PVC pipes, and beverage bottles. Motor vehicle manufacturers are particularly large users of these products. Plastics materials used for mixing and blending resins on a custom basis also are produced in this industry segment.

The segment employing the fewest workers in the chemical industry is agricultural chemicals, which supplies farmers and home gardeners with fertilizers, herbicides, pesticides, and other agricultural chemicals. This segment also includes the formulation and preparation of agricultural and household pest control chemicals.

The paint, coating, and adhesive products segment includes firms making paints, varnishes, putties, paint removers, sealers, adhesives, glues, and caulking. The construction and furniture industries are large customers of this segment. Other customers range from individuals refurbishing their homes to businesses that need anticorrosive paints that can withstand high temperatures.

The cleaning preparations segment is the only one in which much of the production is geared directly toward consumers. This segment includes firms making soaps, detergents, and cleaning preparations. Cosmetics and toiletries, including perfume, lotion, and toothpaste, also are produced in this segment. Households and businesses use these products in many ways, cleaning everything from babies to bridges.

The other chemical products segment includes manufacturers of explosives, printing ink, film, toners, matches, and other miscellaneous chemicals. These products are used by consumers or in the manufacture of other products.

Chemicals generally are classified into two groups—commodity chemicals and specialty chemicals. Commodity chemical manufacturers produce large quantities of basic and relatively inexpensive compounds in large plants, often built specifically to make one chemical. Most of these basic chemicals are used to make more highly refined chemicals used in the production of everyday consumer goods by other industries. Specialty chemical manufacturers, on the other hand, produce smaller quantities of more expensive chemicals that are used less frequently. Specialty chemical manufacturers often supply larger chemical companies on a contract basis. Many traditional commodity chemical manufacturers are divided into two separate entities, one focused on commodities and the other on specialty chemicals.

Table 1. Distribution of wage and salary employment in chemical manufacturing, except pharmaceutical and medicine manufacturing, by detailed industry, 2002
(Employment in thousands)

Industry	Employment	Percent
Total, all industries	636.3	100.0
Basic chemical manufacturing	170.5	26.8
Soap, cleaning compound, and toilet preparation manufacturing	122.1	19.2
Resin, synthetic rubber, and artificial synthetic fibers and filaments manufacturing	114.3	18.0
Paint, coating, and adhesive manufacturing	72.3	11.4
Pesticide, fertilizer, and other agricultural chemical manufacturing	44.7	7.0
Other chemical product and preparation manufacturing	112.4	17.7

The diversity of products produced by the chemical industry also is reflected in its component establishments. For example, firms producing synthetic materials operated relatively large plants in 2002. This segment had 11 percent of the reporting establishments, yet employed 18 percent of those working in the chemical manufacturing industry. On the other hand, manufacturers of paints, coatings, and adhesive products had a greater number of establishments, each employing a much smaller number of workers. This segment comprised 16 percent of the establishments in the chemical industry, yet employed only 11 percent of all workers.

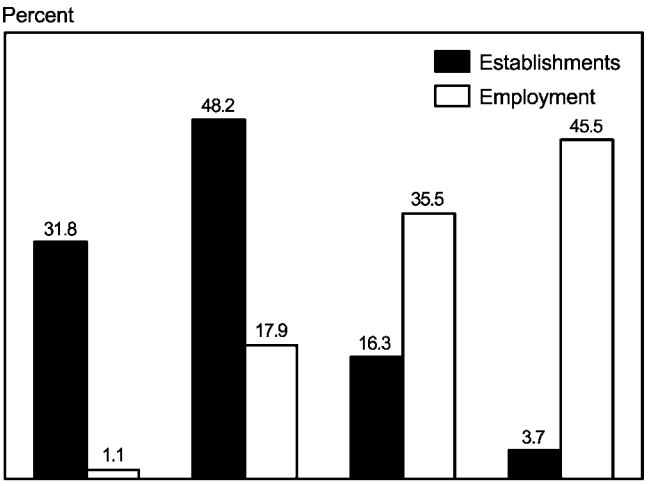
The chemical industry segments vary in the degree to which their workers are involved in production activities, administration and management, or research and development. Industries that make products such as cosmetics or paint that are ready for sale to the final consumer employ more administrative and marketing personnel. Industries that market their products mostly to industrial customers generally employ a greater proportion of precision production workers and a lower proportion of unskilled labor.

Chemical firms are concentrated in areas abundant with other manufacturing businesses, such as the Great Lakes region near the automotive industry, or the West Coast near the electronics industry. Chemical plants also are located near the petroleum and natural gas production centers along the Gulf Coast in Texas and Louisiana. Because chemical production processes often use water, and chemicals are primarily exported by ship all over the world, major industrial ports are another common location of chemical plants. California, Illinois, New Jersey, New York, Ohio, Pennsylvania, South Carolina, Tennessee, and Texas had about half the establishments in the industry in 2002.

Working Conditions

Manufacturing chemicals usually is a continuous process; this means that, once a process has begun, it cannot be stopped when it is time for workers to go home. Split, weekend, and night shifts are common, and workers on such schedules usually are compensated with higher rates of pay. As a result, the average workweek in the chemical industry was 42.1 hours in 2002, 2.0 hours longer than the average for nondurable manufacturing industries, and 8.4 hours longer than the average for all private industries. The industry employs relatively few part-time workers.

Chemical manufacturing, except drugs, employment is concentrated in establishments with 50 or more employees



Most jobs in chemical manufacturing, except drugs, are in large establishments. The largest 20 percent of establishments that employed 50 or more workers in 2002 had over 80 percent of the industry's jobs (see chart). The plants usually are clean, although the continually running machines sometimes are loud and the interior of many plants can be hot. Hardhats and safety goggles are mandatory and worn throughout the plant.

Hazards in the chemical industry can be substantial, but they generally are avoided through strict safety procedures. Workers require protective gear and extensive knowledge of the dangers associated with the chemicals being handled. Body suits with breathing devices designed to filter out any harmful fumes are mandatory for work in dangerous environments.

In spite of the hazards of working with chemicals, extensive worker training on handling hazardous chemicals and chemical company safety measures have resulted in injury and illness rates for some segments of the chemical industry that are much lower than the average for the manufacturing sector. The chemical industry (including pharmaceuticals) reported just 3.3 cases of work-related injury or illness per 100 workers, compared with an average of 7.2 cases for all manufacturing industries in 2002.

Employment

The chemical and allied products industry employed about 636,000 wage and salary workers in 2002, about 4 percent of the total number employed in manufacturing. Most segments of the industry had substantial numbers of jobs, as shown in table 1.

Under the new North American Industry Classification System (NAICS), workers in research and development (R&D) establishments that are not part of a manufacturing facility are included in a separate industry—research and development in the physical, engineering, and life sciences. However, due to the importance of R&D work to the chemical manufacturing industry, chemical-related R&D workers are discussed in this statement even though a large proportion of chemical-related R&D workers is not included in the employment data.

Occupations in the Industry

About half of those employed in the industry work in production and installation, maintenance, and repair occupations. Another 9 percent worked in transportation and material-moving occupations. Eleven percent worked in management, business, and financial; 12 percent in office and administrative support; and about 13 percent worked in professional and related occupations (table 2).

Production. Workers in production occupations operate and fix plant machinery, transport raw materials, and monitor the production process. Improvements in technology gradually are increasing the level of plant automation, reducing the number of jobs in production occupations. Although high school graduates qualify for most entry-level production jobs, advancement into better paying jobs, requiring higher skills or more responsibility, is possible with on-the-job training and work experience or through additional vocational training at a 2-year technical college.

Chemical plant and system operators monitor the entire production process. From chemical ingredient ratios to chemical reaction rates, the operator is responsible for the efficient operation of the chemical plant. Chemical plant operators generally advance to these positions from among the most experienced production workers, usually after having acquired extensive experience and technical training in chemical production processes. Experienced operators sometimes advance to senior supervisory positions.

Industrial machinery mechanics and machinery maintenance workers repair equipment, install machines, or practice preventive maintenance in the plant. Workers advance to these jobs either through apprenticeships or formal vocational training, or by completing in-house training courses.

Inspectors, testers, sorters, samplers, and weighers assure that the production process runs efficiently and that products meet quality standards. They refer problems to plant operators or managers.

Packaging and filling machine operators and tenders wrap products and fill boxes to prepare the final product for shipment or sale to the wholesaler or consumer. Over half of these jobs are in the soap and cosmetics industry, due to the amount of packaging needed for this industry's consumer products.

Transportation and material-moving workers move materials around the plant using industrial trucks or deliver finished products to customers by truck. For these jobs, employers seek experienced workers with knowledge of chemical hazards, safety procedures, and regulations governing the transport of hazardous chemicals. Operation of

Table 2. Employment of wage and salary workers in chemical manufacturing, except drugs, by occupation, 2002 and projected change, 2002-12
(Employment in thousands)

Occupation	Employment, 2002 Number	Employment, 2002 Percent	Percent change, 2002-12
All occupations	636	100.0	-16.7
Management, business, and financial occupations	68	10.7	-13.6
Top executives	14	2.1	-16.0
Marketing and sales managers	6	1.0	-7.7
Industrial production managers	8	1.3	-14.3
Business operations specialists	14	2.2	-12.1
Financial specialists	6	1.0	-14.2
Professional and related occupations	85	13.4	-15.3
Computer specialists	8	1.3	-10.8
Chemical engineers	9	1.4	-18.0
Drafters, engineering, and mapping technicians	8	1.2	-17.6
Chemists and materials scientists	14	2.2	-12.1
Chemical technicians	20	3.1	-16.9
Sales and related occupations	23	3.6	-11.6
Sales representatives, wholesale and manufacturing	18	2.8	-10.8
Office and administrative support occupations	74	11.7	-22.9
Bookkeeping, accounting, and auditing clerks	7	1.1	-24.6
Customer service representatives	8	1.3	-12.0
Shipping, receiving, and traffic clerks	12	1.8	-21.8
Secretaries and administrative assistants	12	1.9	-29.1
Office clerks, general	7	1.1	-23.8
Construction and extraction occupations	7	1.1	-13.8
Installation, maintenance, and repair occupations	52	8.1	-15.7
Industrial machinery mechanics	11	1.7	-10.3
Maintenance and repair workers, general	23	3.6	-16.9
Production occupations	266	41.8	-17.0
First-line supervisors/managers of production and operating workers	24	3.8	-15.1
Assemblers and fabricators	18	2.8	-16.0
Metal workers and plastic workers	23	3.5	-25.1
Textile, apparel, and furnishings occupations	12	1.8	-20.6
Chemical equipment operators and tenders	30	4.7	-17.1
Mixing and blending machine setters, operators, and tenders	31	4.9	-21.4
Inspectors, testers, sorters, samplers, and weighers	11	1.7	-12.0
Packaging and filling machine operators and tenders	27	4.2	-3.5
Helpers—Production workers	12	1.9	-16.6
Transportation and material moving occupations	56	8.9	-16.5
Truck drivers, heavy and tractor-trailer	8	1.2	-13.2
Industrial truck and tractor operators	10	1.6	-11.9
Laborers and freight, stock, and material movers, hand	13	2.0	-27.9
Packers and packagers, hand	11	1.7	-8.4

NOTE: May not add to totals due to omission of occupations with small employment.

industrial trucks and tractors can be learned with on-the-job training, but previous experience driving a truck and a commercial driver's license generally are required to operate a tractor-trailer carrying chemicals. Some jobs in transportation and material movement are open to workers without experience. Workers in these jobs move raw materials and finished products through the chemical plant and assist motor vehicle operators in loading and unloading raw materials and chemicals. They learn safe ways to handle chemicals on the job and develop skills that enable them to advance to other occupations.

Research and development. Most workers in research and development have at least a college degree, and many have advanced degrees.

Chemists and materials scientists carry out research in a wide range of activities, such as analysis of materials, preparation of new materials or modification of existing ones, study of process chemistry pathways for new or existing products, and formulations of cosmetics, household care products, or paints and coatings. They also try to develop new chemicals for specific applications and new applications for existing chemicals. The most senior chemists sometimes advance to management positions. Although chemical companies hire some chemists with bachelor's degrees, a master's or doctoral degree is becoming more important for chemist jobs.

Chemical engineers design equipment and develop processes for manufacturing chemicals on a large scale. Chemical research engineers design and conduct experiments to learn how processes behave and conduct research for potential new chemical products and processes. A bachelor's degree is essential for these jobs, and a master's degree may be preferred or required for some jobs.

Engineering and *science technicians* assist chemists and engineers in research activities and may conduct some research independently. Those with bachelor's degrees in chemistry or graduates of 2-year technical institutes usually fill these positions. Some graduates of engineering programs start as technicians until an opportunity to advance into an engineering position arises.

Administration and management. Most managers need a 4-year college degree in addition to experience in the industry. As in other highly technical industries, top managerial positions often are held by those with substantial technical experience. Employment in administrative support and managerial occupations is expected to decline as companies merge and consolidate operations.

Engineering managers conduct cost estimations, perform plant design feasibility studies, and coordinate daily operations. These jobs require a college degree in a technical discipline, such as chemistry or chemical engineering, and experience in the industry. Some employees advance from research and development positions to management positions.

Advertising, marketing, promotions, public relations, and *sales managers* promote sales of chemical products by informing customers of company products and services. A bachelor's degree in marketing, chemistry, or chemical engineering usually is required for these jobs.

Office and administrative support workers perform office functions such as secretarial duties, bookkeeping, material records processing, and other clerical duties. Training beyond high school and familiarity with computers is preferred for these occupations.

Training and Advancement

Despite recent reductions in the workforce, the chemical industry offers career opportunities for persons with varying levels of experience and education. Training and advancement differ for the three major categories of occupations.

Production workers may start as laborers or in other unskilled jobs and, with experience and training, advance into better paying positions that require greater skills or have greater responsibility. Substantial advancement is possible even within a single occupation. For example, chemical plant operators may move up through several levels of responsibility until they reach the highest paying operator job. Advancement in production occupations usually requires mastery of advanced skills. Such skills usually are the result of a combination of on-the-job training and formal training provided by the employer. Some workers advance into supervisory positions.

Most jobs in research and development require substantial technical education after high school, but opportunities exist for persons with degrees ranging from a 2-year associate degree up to a doctorate. Development of new products and the award of patents bring increases in pay and prestige but, after a point, advancement may require moving from research and development into management. Researchers usually are familiar with company objectives and production methods, which, combined with college education, equips them with many of the tools necessary for management positions.

Managerial jobs usually require a 4-year college degree, though some may require only a 2-year technical degree. Managers can advance into higher level jobs without additional formal training outside the workplace, although competition is keen. In general, advancement into the highest management ranks depends on experience and proven ability to handle responsibility in several functional areas. Among larger, multinational firms, international experience is important for career advancement. Also, industry restructuring has left fewer layers of management, intensifying competition for promotions.

Earnings

Earnings in the chemical industry are higher than average. The weekly earnings for all production workers in chemical manufacturing averaged $755 in 2002, compared with $619 in all manufacturing industries and $506 throughout private industry. This was due, in part, to the chemical industry's practice of assigning more overtime and weekend work, which commands higher hourly rates.

Wages of workers in the chemical industry vary according to occupation, the specific industry segment, and the size of the production plant. Earnings by major occupation group are shown in table 3.

The principal unions representing chemical workers are the PACE (Paper, Allied-Industrial, Chemical, and Energy Workers) International Union and the International Chemical Workers Union. In 2002, almost 14 percent of chemical manufacturing workers were union members or covered by union contracts, compared with about 15 percent of all workers.

Table 3. Median hourly earnings of the largest occupations in chemical manufacturing, except drugs, 2002.

Occupation	Chemical manufacturing	All industries
Chemists	$26.20	$25.43
First-line supervisors/managers of production and operating workers	24.87	20.64
Chemical plant and system operators	21.18	21.12
Maintenance and repair workers, general	19.99	14.12
Chemical technicians	19.86	18.00
Chemical equipment operators and tenders	18.93	18.00
Inspectors, testers, sorters, samplers, and weighers	14.53	13.01
Mixing and blending machine setters, operators, and tenders	14.20	13.23
Packaging and filling machine operators and tenders	12.04	10.20
Team assemblers	10.55	10.90

Outlook

Although the chemical industry's output is expected to grow, employment in the chemicals manufacturing industry, excluding pharmaceuticals and medicine, is projected to decline by about 17 percent over the 2002-12 period, compared with 16-percent growth expected for the entire economy. The projected decline in chemical manufacturing employment can be attributed to trends affecting the U.S. and global economies. There are several factors that will influence chemical industry employment, such as more efficient production processes and increased plant automation, the state of the national and world economy, company mergers and consolidation, increased foreign competition, the shifting of production activities to foreign countries, and environmental health and safety concerns and legislation. Another trend in the chemical industry is the rising demand for specialty chemicals. Chemical companies are finding that, in order to remain competitive, they must differentiate their products and produce specialty chemicals, such as advanced polymers and plastics designed for customer-specific uses—for example, a durable body panel on an automobile.

Improvements in production technology have reduced the need for workers in production; installation, maintenance, and repair; and material-moving occupations, which account for large proportions of jobs in the chemical industry. The application of computerized controls in standard production, and the growing manufacture of specialty chemicals requiring precise, computer-controlled production methods, will reduce the need for workers to monitor or directly operate equipment. Although production facilities will be easier to run with the increased use of computers, the new production methods will require workers with a better understanding of the use of the systems.

Foreign competition has been intensifying in most industries, and the chemical industry is no exception. The increase in international trade and rapidly expanding foreign production capabilities should intensify competition. Pressure to reduce costs and streamline production will result in mergers and consolidations of companies both within the United States and abroad. Mergers and consolidations are allowing chemical companies to increase profits by eliminating duplicate departments and shifting operations to locations in which costs are lowest. U.S. companies are expected to move some production activities to developing countries—those in East Asia and Latin America, for example—to take advantage of rapidly expanding markets.

The chemical industry invests billions of dollars yearly in technology to reduce pollution and clean up existing waste sites. Concerns about chemicals and the environment may spur producers to create chemicals with byproducts that are fewer or less dangerous, or that can be recycled or disposed of cleanly.

The factors affecting employment in the chemical manufacturing industry will impact different segments of the industry to varying degrees. The only segment projected to add jobs is the cleaning preparations, including soap, cleaning compounds, and toilet preparations segment, with an increase of about 3,200 jobs. The other chemical products segment is projected to lose about 33,000 jobs; the basic chemical manufacturing segment, about 31,000 jobs; and the synthetic materials segment, about 26,000 jobs.

Sources of Additional Information

Additional information on training and careers in the chemical manufacturing industry is available from:

- American Chemical Society, 1155 16th St. NW., Washington, DC 20036. Internet: **http://www.acs.org**
- American Institute of Chemical Engineers, 3 Park Ave., New York, NY 10016-5991. Internet: **http://www.aiche.org**

Detailed information on many occupations in the chemical manufacturing industry, including the following, may be found in the 2004-05 edition of the *Occupational Outlook Handbook*.

- Chemical engineers
- Chemists and materials scientists
- Industrial production managers
- Inspectors, testers, sorters, samplers, and weighers
- Material-moving occupations
- Science technicians